Clinical Investigation

Rock-Climbing Injuries in Yosemite National Park

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This study was presented in part at the annual meeting of the Wilderness Medical Society at Aspen, Colorado, in August 1986 and at "Mountain Medicine 1987," Leavenworth, Washington, in November 1987.

We questioned 220 injured rock climbers or their partners seen consecutively at the Yosemite (California) Medical Clinic over 3½ years regarding details of their accidents. Injury type and location were extracted from medical records and severity quantified. The National Park Service rescued 27% of the climbers. Injured climbers were characteristically male (88%) and experienced (mean 5.9 years) and typically fell while leading climbs (66%). Among 451 injuries, 50% were to the skin or subcutaneous tissues, while 28% involved the lower extremity and were predominantly fractures. In terms of each climber's most severe injury (n = 220), 45% involved the lower extremities (30% from the ankle alone). Head injury or hypothermia caused 12 of 13 fatalities, showing the lowest case-fatality rate reported to date among injured climbers (6%). Rescue personnel successfully managed airways in victims of head injuries, anticipated and treated complications of hypothermia, and stabilized fractures. Victims requiring immediate extensive surgical intervention or blood transfusion usually died before rescue could be effected.

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Many studies of climbing injuries have been carried out around the world but none in what has been called "the climbers' Mecca"—Yosemite National Park, California. In 1953 Ferris estimated that there were 18,722 "man-mountain days" for the entire United States.[1] By 1987 Yosemite alone hosted an estimated 25,000 to 50,000 climber-days (John Dill, Yosemite Search and Rescue, US National Park Service, oral communication, July 1987). As the participation in this sport has increased, so has the number of injuries.[2]

Most mountaineering medical literature has stressed severe injuries, snow-related accidents, and high-altitude physiology.[2-7] For example, Foray and co-workers, in an analysis of 1,819 mountain-climbing accidents in the Chamonix-Mont-Blanc region, found 69% of all cases classifiable as "trauma"; 22% as "exposure to cold"; and the rest as "mountain sickness, severe fatigue, and accidents due to thunderbolts."[7] Climbers on Mount McKinley (Alaska) in 1976 commonly suffered acute mountain sickness or frostbite in addition to fractures.[5] In the Grand Tetons (Wyoming), much morbidity and most climber mortality were attributed to travel on snow,[2] while most injured climbers studied in the eastern Sierra Nevada (California) had acute mountain sickness or hypothermia in addition to trauma.[6] No one has described injury patterns in a relatively low-altitude, snow-free area such as Yosemite, where nearly all climbing occurs on rock.

Injury rates have been estimated in other regions, where climber registration is required.[2,5] Climbers are not required to register in Yosemite, and injury rates there cannot be determined. A different measure, the "case-fatality rate"—the percent of fatalities among all injured climbers—has been useful, therefore, by giving information about the lethality of injury. Many studies of climbing injuries have yielded high case-fatality rates—as high as 41%.[1,2,5,7] These studies, however, used data extracted from rescue or anecdotal reporting only, not data collected at local medical facilities where minor injuries of self-rescued climbers are often treated. Injuries may appear inappropriately severe because of this selection bias, leading to a distorted perception of climbing risks.

Yosemite National Park offers a unique environment where minor injuries can be documented as completely as severe injuries. The park is a remote area served by a single medical clinic that also acts as the medical base station for all rescues.

Another measure of injury, the Injury Severity Score (ISS),[8] has been used to assess injury severities among climbers.[2] No one has yet evaluated the usefulness of adapting the ISS to the study of climbing injuries.

This descriptive study was initiated to define the mechanism, pattern, and severity of rock-climbing injuries in Yosemite; to evaluate the care of those injuries; and to identify strategies for reducing the number of injuries where suggested by particular injury patterns. It was hypothesized that without the mountaineering hazards of high altitude, cold, avalanches, and long slides on snow, the spectrum of injuries in Yosemite would be different from that previously reported

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ABBREVIATIONS USED IN TEXT
AIS = Abbreviated Injury Scale
ISS = Injury Severity Score

in the literature from other climbing areas. This study did not attempt to determine the rate of injury in Yosemite.

Background Terminology

A "climber" was defined as anyone familiar with climbing techniques, nomenclature, and rating systems standard in the United States. Deliberately excluded were injuries involving "scramblers," persons climbing rocks despite an unfamiliarity with rating systems or the use of ropes.

"Climbing injuries" include those injuries suffered by climbers during approach or execution of or descent from a climb. Customarily, a "lead" climber, attached to a rope, begins climbing as the "following" climber plays out the rope. The leader places devices in the rock—"protection"—through which the rope can slide and support the climber if he or she falls. Once in a safe position, the leader anchors to rock and takes up rope as the follower climbs. "Free climbing" implies the use of only the climber's body and extremities, relying on "protection" only in the event of a fall, whereas "aid climbing" uses the "protection" for support as well as safety on steeper, longer climbs. "Bouldering" denotes unroped practice climbing, usually within 5 m (15 ft) of the ground. A "rappel" is a descent by sliding down a rope, usually using a metal device. For further explanation of climbing terminology, readers are referred to Royal Robbin's *Basic Rockcraft*.[9] Among fifth-class climbs—climbs generally requiring a safety rope—difficulty is denoted in Yosemite using a decimal scale of roughly equivalent increments, designated 5.1 to 5.13.

Patients and Methods

Beginning in April 1984, data were collected using questionnaires completed by all injured climbers or their partners who were seen at the Yosemite Medical Clinic or rescued by the US National Park Service's Search and Rescue team. No one refused to complete the questionnaire.

Questionnaires solicited standard demographic data; previous climbing experience; the route and difficulty of the climb; and details of the accident, including cause, length of fall, and mechanism of injury. Drug or alcohol use was recorded, when reported. Yosemite Search and Rescue records were reviewed to determine the medical interventions used by park rescuers.

Injury data were extracted from clinical records or autopsy reports and coded according to anatomic regions. Injury "type" was classified as "fracture," "sprain," or "laceration," for example. The severity of each injury was quantified using the Abbreviated Injury Scale (AIS)[10] on a scale of 1 to 5 reflecting threat to life: minor to virtually unsurvivable. Overall injury severity of multiple injuries was calculated using the Injury Severity Score (scale 0 to 75), which is mathematically derived by adding the squares of the highest AIS code for each of the three most severely injured body regions.[8] Injury "site" and "type" were analyzed for all injuries suffered by all climbers and for the subset of "single most severe injuries" suffered by each climber.

Some climbers severely injured in remote regions of the park were rescued by the Park Service and flown by helicopter directly to definitive hospitals outside the park. The Yosemite clinic monitored all such evacuations, and data were collected from the medical records of those hospitals. Any injured climbers who rescued themselves and received medical care at home or elsewhere could not be detected by this study. These "drive-aways" were felt to be few and to have minor injuries because the remote location of Yosemite made it difficult for them to seek care elsewhere.

Data were analyzed using the "Excel" and "Statview 512+" data-base and statistical software programs. For hypothesis testing we used χ^2 analysis, unpaired Student's t test, and, where applicable, the Mann-Whitney equivalent of the Student's t test or the Spearman's rank correlation coefficient for nonparametric data (the Injury Severity Score, for example, does not follow a normal distribution in this population; thus, the Student's t test is invalid for this variable).

Results

In 3½ climbing seasons, 220 injured climbers were treated for 451 injuries for an average of 2 injuries per victim; 27% were rescued by the Park Service, the rest being first seen at the Yosemite Medical Clinic. Thirteen climbers died (case-fatality ratio 6%).

Of the injured climbers, 88% were male, and the mean age was 27.5 years (range, 14 to 64 years). The mean number of years of climbing experience was 5.9 years (men 6.2, women 3.6, $P < .005$). The injured climbers had climbed an average of 11 days in the 30 days preceding their injury. About 31% reported a previous climbing injury more severe than minor abrasions, of which 60% were to the lower extremities. Most victims (63%) were from California; 19% were foreign, representing 14 nations. A total of 71% reported being able to lead climbs of 5.10 or harder. During the 30-day period before injury, most climbers were climbing at or near their maximal ability (correlation coefficient = .91). Only a minority of falls (14%) occurred when victims were attempting climbs rated beyond their most recent standard (correlation coefficient = .74). Six reported using helmets on the day of injury. One reported using drugs or alcohol immediately before injury.

More injuries occurred in the spring (47%) than in summer or autumn (21% and 26%, respectively). Injuries were disproportionately higher on weekends (43% on Saturdays and Sundays alone) than on weekdays (57% over the five days) ($P < .0001$). Time of injury was distributed evenly about a peak at noon, although the number of "severe"—ISS > 12[11]—injuries was disproportionately increased after 5 PM (35%, $P < .02$). No area of Yosemite was represented disproportionately, except for the Cathedral Rocks area, where severe injuries were more frequent ($P < .001$). The average clinic medical expense for climbers was $233, while rescued climbers averaged clinic expenses of $360. Nearly all (89%) climbers paid their clinic bills in full.

Mechanism of Injury

Falls suffered by the lead climber were responsible for the majority of injuries (66%, $P < .05$) (Table 1). Length of falls ranged from 0.6 to 244 m (2 to 800 ft; mean 13 m [43 ft], median 8 m [25 ft]). On 29% of leader falls, "protection" pulled out of the rock during a fall, resulting in a longer fall (mean fall length 17 m [55 ft]; $P = .05$). Only 12% of injuries occurred while "aid" climbing. Six climbers were injured (one fatally) while climbing without a rope, and seven were

TABLE 1.—*Immediate Event Leading to Injury*

Event	Injury No.	Injury %
Leader fall	144	65
Bouldering fall	14	6
Rock fall	13	6
Illness	12	6
Exposure	11	5
Follower fall	4	2
Anchor failure	3	1
Rappel	2	1
Other	17	8
	220	100

TABLE 2.—*Injuries by Body Region*

Body Region	All Injuries No.	All Injuries %	Single Most Severe Injury No.	Single Most Severe Injury %
Skin/subcutaneous	227	50	65	30
Lower extremity				
Femur	7	2	5	2
Knee	10	2	8	4
Tibia/fibula	15	3	9	4
Ankle	81	18	66	30
Foot	14	3	10	5
	127	28	98	45
Upper extremity				
Shoulder	4	1	2	1
Forearm	6	1	3	1
Wrist	8	2	4	2
Hand	11	3	8	4
	29	6	17	8
Skull/brain	25	6	14	6
Thorax				
Chest	5	1	3	1
Thoracic spine	6	1	4	2
	11	2	7	3
Face/neck	10	2	3	1
Abdomen	6	1	2	1
Bony pelvis	4	1	2	1
Hypothermia	12	3	11	5
Unknown	...	...	1	0
	451	100	220	100

TABLE 3.—*Types of Climbing Injuries at Yosemite National Park*

Type	All Injuries No.	All Injuries %	Single Most Severe Injury No.	Single Most Severe Injury %
Fracture	130	29	85	39
Abrasion	111	25	21	10
Contusion	66	15	19	9
Laceration	64	14	32	14
Sprain/strain	47	10	35	16
Hypothermia	12	3	11	5
Dislocation	9	2	8	4
Closed space hemorrhage	6	1	4	2
Concussion	5	1	3	1
Other	1	0	1	0
Unknown	...	...	1	0
	451	100	220	100

injured while descending without a rope. Rappelling contributed only 1% of all injuries. There was one case of equipment failure when a protection bolt drilled previously into the rock pulled out under the force of a fall.

Four following climbers were injured. Followers are usually considered to be in a safe position while climbing because the climber above pulls up the rope as the follower ascends, preventing all but short falls. In two of the accidents, the followers were traversing sideways when they fell, causing a pendulum-like fall to occur, of greater distance and force than most follower falls. One fatality occurred when a follower was hit by a huge boulder dislodged by his lead climber's fall. The final follower accident resulted from inadequate belay from above.

Most injuries occurred on rock ledges or rock face (47%), while falls to the ground and falling rock caused 27% and 10% of injuries, respectively. Weather was a factor in 23 cases, 3 fatal (hypothermia). The most unusual sources of injury included a bat bite and an episode of assault by another climber with a piton hammer.

Pattern of Injury

Climbers' injuries are shown by body region in Table 2. Among all 451 injuries, regardless of severity, most (50%) were to the skin or subcutaneous tissues. After excluding these injuries, which were almost always minor, 57% of the remaining 224 injuries were to the lower extremities. Among all injury types, predominantly external injuries (lacerations, contusions, and abrasions) were the most common (together 53%), then fractures (29%), and sprains (10%) (Table 3). Most (63%) fractures were to the lower extremity (primarily to ankle, tibia or fibula, and foot). The site and type of skeletal injuries are depicted in Figure 1.

The injury site and type were also analyzed by each climber's single most severe injury (n = 220) because most climbers presented with one severe injury and one associated minor complaint, typically abrasions. Ankle injuries alone—mostly fractures—made up 30% of climbers' single most severe injuries, making the ankle the most commonly injured body region causing climbers to seek medical attention. More than 44% of climbers presented with complaints relating to some part of the lower extremity. Only 6% of single most severe injuries were attributed to head trauma, but 9 of these 14 were fatal. More than a fourth of climbers presented with only skin or subcutaneous tissue injuries, nearly always of minor severity.

Injury Severity

Injury severity scores are depicted in Figure 2. Eleven hypothermia cases could not be coded because hypothermia is not included among diagnoses in the Abbreviated Injury Scale. Notably, the vast majority of injuries were minor. The median ISS was 4.0 (mean 6.1). The group of cases rescued by Search and Rescue teams had a median ISS of 9, while the median for cases first presenting to the clinic was 4 ($P < .05$). The median ISS was 4 for both male and female subgroups. "Minor" injuries (ISS less than 5)[11] made up 59%, "moderate" (ISS from 5 to 12) were 36%, and "severe" (13 to 75) were 5%. The ISS was greater for lead climbers (median 4) than for followers (median 1, $P < .01$).

The ISS was positively correlated with the length of fall ($r = .86$) (Figure 3). Correlation was poor ($r = .42$), however, when the two longest falls were excluded (both 243 m [800

ft], ISS 75). For severe injuries—an ISS of greater than 12—the relationship between the length of fall and injury severity was stronger ($r = .91$ without the two outlying cases). Most falling lead climbers were stopped by their ropes and safety systems (63%), attenuating the impact.

Time to Medical Care

The median time of arrival by park medics was 1.5 hours after injury (range, 10 minutes to 36.5 hours). After a Search and Rescue team arrived, the median time for stabilization and transport to clinic, where applicable, was 1.6 hours (range, 1 to 38.5 hours). Victims transported to tertiary care centers arrived a median of 7.25 hours after injury (range, 2 to 38.5 hours). Self-rescued climbers presented to the clinic after a median of 4.25 hours (range, 15 minutes to 2 weeks).

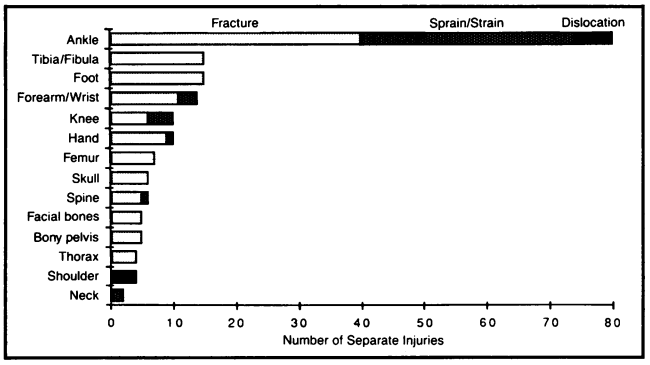

Figure 1.—The graphs show the site and type of skeletal or joint injuries (n = 183).

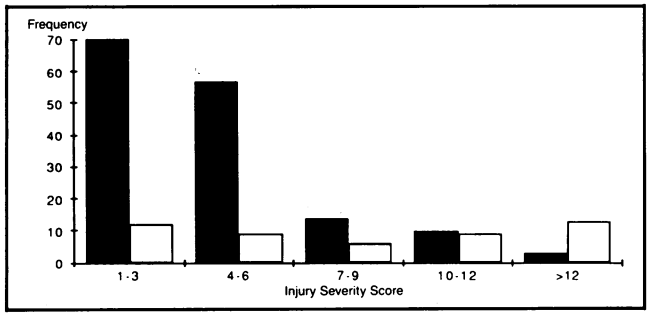

Figure 2.—The graphs show the different frequencies of Injury Severity Scores (scale of 1 to 75) between self-rescued climbers **(solid bars)** and climbers rescued by the Yosemite National Park Service **(empty bars)** ($P < .05$).

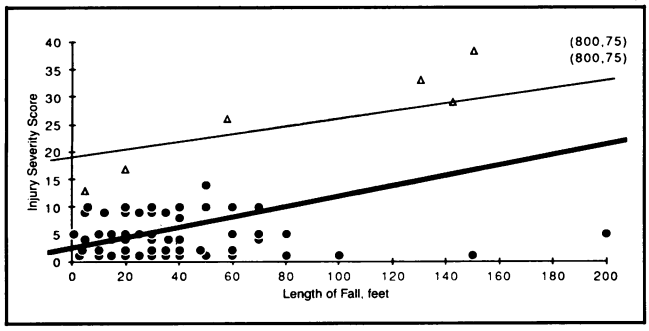

Figure 3.—The graphs show climbing injury severity scores (ISSs) at various fall lengths (mean 42.8 ft, median 25 ft). Two fatalities, both 800-ft falls with ISS 75, are not shown because of scale. △ = severe injuries ($r = .975$ [$r = .914$ if 800-ft falls are excluded]), ● = all injuries ($r = .858$ [$r = .419$ if 800-ft falls are excluded])

Severe Injury Cases

Of the 220 injured climbers, 20 were considered severely injured (ISS > 12), and 13 of these died. The seven survivors had injury severity scores ranging from 13 to 22. Fatally injured climbers had scores from 26 to 75. Injuries among the survivors included two cerebral contusions, a Le Fort I (horizontal maxillary) fracture, three wrist fractures (one crushed), multiple lacerations, an open skull fracture, an open digital fracture, a femoral neck fracture, a case of multiple pelvic fractures, a bladder contusion, an open trochanteric fracture, a case of three rib fractures, a dislocated ankle, and multiple contusions and abrasions ranging from mild to severe. Severely injured climbers had disproportionately fewer lower extremity injuries than mildly or moderately injured climbers ($P < .0001$). Severe injury was associated with occurrence after 5 PM ($P < .02$), with inclement weather ($P < .05$), with climbing further above the ground (mean pitch at injury = ninth versus third pitch for climbers not severely injured; ($P < .001$), and with longer fall (mean 62 m [203 ft], $P < .0001$). Severe injury was also more frequent in the Cathedral Rocks area ($P < .001$).

Medical Intervention

Medical intervention by rescue personnel was difficult and often delayed by technical rescue problems. In general, Park Service medics stabilized injured climbers using mask or nasal oxygen, oral or esophageal obturator airways, administering isotonic crystalloid solutions, or applying cervical collars, backboards or Kendrick extrication devices, and air splints. These interventions slowed, but did not preclude, rescue by litter lowering, carrying out, or air evacuation. At the clinic, airway patency and respiratory and circulatory sufficiency were established and associated injuries investigated. One injured climber required intubation, but no tube thoracostomies were needed. Two climbers with tachycardia, diaphoresis, and peripheral vasoconstriction responded promptly to the intravenous administration of Ringer's lactated solution. If blood transfusions had been needed, the clinic would have requested units to be flown to the park with an air transport team. Appropriate radiographic studies were carried out. All identified orthopedic injuries were stabilized by plaster splinting or traction, and 14 climbers were then transferred by helicopter or ground transportation to receiving hospitals where definitive surgical interventions occurred.

Fatalities

Of 220 climbers injured in Yosemite during the study period, 13 died, yielding a case-fatality rate of 6%. In 11 of the 13 fatal cases, death occurred before rescuers arrived. Two fatally injured climbers survived until after arrival at the Yosemite Clinic, one dying of hypothermia and the other of head injuries sustained in a leader fall. Two other climbers died of hypothermia incurred during autumn storms, four others died of head trauma sustained in leader falls, and one died of head injury after rappelling off the end of his rope. Another climber died of abdominal hemorrhage incurred from a rock fall while sleeping, two others fell together 243 m (800 ft) when their belay anchor failed, dying of massive head and internal injuries, and one climber died of head injuries caused by rock fall. The pathologist who did the autopsies on most of the fatalities believes that helmet use

might have prevented some deaths from head trauma (James Wilkerson, MD, oral communication, January 1987).

Discussion

This study has shown that the vast majority of rock-climbing injuries in Yosemite National Park are minor. The large number of self-rescued climbers detected by monitoring the clinic cases in addition to the more severely injured rescued cases contributed dramatically to lowering the median injury severity score for the combined group. This preponderance of low injury severity scores has also been seen among injured climbers in the Grand Tetons.[2]

The pattern of injury among Yosemite climbers is remarkable for frequent injury to the skin or subcutaneous area and to the lower extremities. The high frequency of contusions, lacerations, and abrasions apparently results from the blunt, glancing, or abrasive forces that occur as the climbers fall.

A preponderance of lower extremity injuries has also been documented among injured climbers in the Grand Tetons[2] and in the eastern Sierra Nevada, with trauma in the latter area predominantly to the ankle or distal third of the tibia.[6] Most of the injuries among climbers in the Chamonix-Mont-Blanc region were also to the extremities (56%) and particularly involved ankle fractures.[7] Thus, injured Yosemite climbers tended to have an injury pattern similar to the patterns described from other areas, with the exception of acute mountain sickness, frostbite, and hypothermia, which have occurred with greater frequency in higher, colder climbing regions.

The high frequency of lower extremity injuries among climbers has been attributed to inadequate "isokinetic strength training."[6] We suggest that lower extremity injury is simply a function of a high energy transfer to a small area of the body, regardless of strength, as evidenced by the high incidence of fracture. The high incidence of foot and ankle injuries among injured climbers provides evidence that climbers strike the rock in an upright position as they fall. The rare occurrence of head injury in this study also supports this concept. A similar pattern of injury is also seen in victims of elevator falls and in injured parachutists. Maull and associates described the cases of six victims injured when an elevator malfunctioned and fell three stories to the ground. All six patients sustained fractures below the knee.[12] Ciccone and Richman reviewed 2,709 cases of fractures sustained by parachuting and found 86% of these to be confined to the lower extremities.[13] An urban series of 161 falls from a height also revealed multiple fractures as the most common injury and in the same predictable distribution involving the lower extremities, pelvis, and spine.[14]

Several cases at the shorter fall lengths show why injury severity among injured climbers did not correlate better with length of fall. In one case, a woman fell 30 m (100 ft) while leading a near vertical pitch, and her belayer failed to arrest her fall until the rope jammed in a carabiner. She hit scarcely any rock on the way down, receiving only a small laceration and minimal contusions (ISS 1). When the rope jammed, it decelerated her elastically, imparting no further injury. Modern climbing ropes have an important elastic property: the greater the length of rope between falling climber and belayer, the longer the distance over which the climber is decelerated. In another case, a climber fell only 2 m (6 ft) but smashed into a highly angulated ledge, suffering a compound fracture of the femur and severe abrasions (ISS 13). A third climber fell just 6 m (20 ft) but hit the ground, sustaining a concussion, rib fractures, and a dislocated ankle (ISS 17). In these cases, injury severity may have been determined more by the shape of a rock ledge, the angle of impact, and the body surface area striking rock than by the length of the fall.

The average experience level among injured climbers was high: 60% of injured climbers in Yosemite had more than three years of experience, and 71% of them could lead climbs rated 5.10 or above in difficulty. In contrast, only 21% of those injured climbing in the eastern Sierra Nevada had more than five years of active climbing experience.[6] Similarly, the majority of climbing victims in the Grand Tetons had been climbing less than a year.[2] Only 24% of all injured climbers recorded in American Alpine Club data between 1951 and 1983 had more than three years' experience (H.A.A., unpublished data, compiled May 1986). The high level of experience among injured Yosemite climbers suggests either that relatively few beginners are climbing in Yosemite or that beginning climbers are less often injured than are experienced climbers. Preliminary climber census data support the former explanation (T.K.H., unpublished data, compiled November 1987).

This study documents the lowest case-fatality rate reported to date (6%). This can be contrasted to the case-fatality rate reported among climbers injured on rock in the United States between 1951 and 1960 (41%),[1] in the Grand Tetons (19%),[2] on Mount McKinley (9%),[5] and in the eastern Sierra Nevada (8%).[6] Our results are in accord with another large rock-climbing series in the European literature that found "serious sequelae" in only 4% of 114 rock climbers treated in hospital.[15] In Yosemite, most of the injured climbers found their own way to the clinic. All but one severely injured climber required Park Service rescue. The large discrepancy in ISSs between Park Service-rescued and self-rescued case groups supports the hypothesis that many earlier studies have overrepresented severely injured cases by relying on search and rescue data. Furthermore, some injured climbers undoubtedly left Yosemite unrecorded, to receive medical care at home. Including these "drive-aways" would have lowered our median ISS still further.

The isolated nature of most climbing accidents impairs a rapid and definitive medical intervention. Nonetheless, at the Yosemite Clinic, the outcome among severely injured climbers was probably not adversely affected by the lack of capability for extensive surgical intervention or blood transfusions. All but one person who would have benefited by such interventions died before rescuers could reach them. In the one case of hypothermic fatality transported to the clinic, immediate access to cardiopulmonary bypass rewarming might have been helpful though impractical. If rescue times are lowered, then the time to surgical intervention and intensive care will also have to be lowered to increase survival.

The injury pattern seen among Yosemite climbers suggests certain ameliorative strategies. Among fatally injured climbers, weather and head injuries played predominant causal roles. Head injuries, though rare, were often severe. As noted by the park's pathologist, using a helmet might have prevented some deaths. Nonetheless, international standards only require helmets to withstand impact energies equivalent to that generated by a 5-kg object falling 2 m onto a helmet,[16] similar to a relatively short fall. Also, because head trauma is

a rare event, helmet use would have to become almost universal to significantly reduce mortality.

The frequent occurrence of abrasions or lacerations might be ameliorated by the use of tough, durable clothing. Efforts to reduce lower extremity injury could include devising shoes to absorb and diffuse impact. Unfortunately, climbers complain of overheating and restriction of movement caused by excess clothing, and bulky shoes are considered unacceptable. Careful attention to weather forecasts and preparation with equipment for inclement weather could reduce morbidity and mortality due to hypothermia, even in a rarely snowy environment like Yosemite.

The Injury Severity Score was a useful tool for the study of climbing injuries. All climbing injuries, except hypothermia, could be scored using the Abbreviated Injury Scale, originally designed for motor vehicle and highway-related injuries.[10] The ISS successfully distinguished between the more severely injured climbers requiring rescue and the less severely injured, self-rescued climbers. We would hypothesize that AIS scores—and therefore ISS—could be applied to hypothermic patients also, if fatality rates for values of a suitable diagnostic marker, such as core temperature, could be established for a large sample of cases. The ISS appears useful to compare preventive, rescue, and medical intervention systems of different regions where climbing injuries occur.

Conclusion

This study shows that the typical rock-climbing injury in Yosemite National Park was a nonfatal injury to the lower extremities with associated superficial injuries. Injury typically occurred in a highly experienced, usually male, climber who fell while leading a climb. Injury severity scoring was a useful tool to document the minor severity of most injuries. Most fatalities were due to head trauma or hypothermia. Rescue personnel had to manage airways successfully in head-injured victims, anticipate and treat complications of hypothermia, and stabilize frequent fractures. The receiving medical clinic was required to secure airways and ventilation, establish adequate circulation, identify and stabilize orthopedic and associated injuries, and prepare some patients for transport to definitive facilities. The rural clinic could adequately stabilize nearly all cases of climbing injuries because victims requiring immediate surgical intervention or blood transfusion usually died before rescue could be effected.

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